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Standardization of no-passing zone pavement markings

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STANDARDIZATION OF NO-PASSING ZONE PAVEMENT MARKINGS

BY

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PREFACE

This thesis is a comprehensive treatment of present methods practiced by the various Highway Departments in the United States. It presents in particular current methods used by the State Highway Departments and the Public Roads Administration in marking no-passing zones throughout the country.

For a long time it has seemed to the author that such a study was needed by both students and highway engineers. Road-design information of great value has developed over the years and often has been published but never assembled in a single orderly presentation stripped of excessive overlapping.

Free reference has been made to the publications of the American Association of State Highway Officials, the Highway Research Board, and the American Society of Civil Engineers. Help from all these sources is gratefully acknowledged.

The author has received helpful suggestions from many of the State Highway Commissions which is appreciated. He particularly acknowledges his indebtedness to Professor Ernest W. Carlton, Professor of Structural Engineering and member of the Graduate Committee of the University of Missouri, School of Mines and Metallurgy, who very kindly read the original manuscript and for his criticism and valuable suggestions.

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INTRODUCTION

There has been and is a wide variety of marking and signing no-passing zones on highways throughout the United States. The first no-passing pavement marking was a single line laid down on the highway center line through hazardous zones, particularly zones of limited sight distance. Whether or not it had any legal authority, it at least gave a warning of danger. It also was a convenient guide line, and many states began to place such a line throughout the entire length of the principal highways.

Marking the center line continuously destroyed its value as a no-passing marking. Double lines or differently colored lines had to be used in no-passing zones. Finally it was recognized that it is not sufficient merely to distinguish between the continuous center line and the special line used in hazardous zones.

No-passing zones are not identical in location or extent for the opposing directions of traffic. A single line, or any type of striping that is designed only to be distinct from the normal center line, cannot take account of these directional differences in the extent of no-passing zones. It must make the zones in both directions identical. Hence, it must be regarded as merely a warning or as a positive barrier, in which latter case it unnecessarily restricts traffic flow by preventing passing even under favorable conditions.

The signing and marking of no-passing zones of the roads by the State Highway Departments is an essential element in the completion of a highway transportation system. In order that a highway signing and marking no-passing zones program function with maximum efficiency, the signs and markers themselves must be standardized throughout the United States.

In order to promote public safety and convenience, certain laws and regulations have been adopted by the individual States pertaining to the use of our highways. In general, rules governing the operation of motor vehicles are understood. For instance, it is unnecessary to erect signs stating that vehicles should keep to the right of the road while meeting other vehicles. There are, however, certain legal requirements not quite so obvious because of the restricted number of locations at which compliance is required. The motorist, for his own well being, must be informed of such rules or regulations; therefore, various regulatory signs and markings are placed on our highways to indicate such legal requirements. Disobedience of these constitutes an infraction of the law and should be so regarded by all citizens.

While there has been a practical unanimity of opinion to the effect that the marking of no-passing zones is not only desirable but that such marking is an important safety factor, there can be no question but that the differences in no-passing zone marking practices are confusing to out-of-state drivers encountering systems different from that used in their own states. Differences in no-passing zone markings confronting a driver outside the boundaries of his own state are undoubtedly not only confusing but may in fact be hazardous because of the possibility of a driver misinterpreting the meaning of a system of marking with which he is unfamiliar. In order to retain respect and to accomplish the desired results, signs and markings of no-passing zones should always be consistently applied.

Many variable factors enter into the designation of no-passing zones, and it is necessary to consider all of them in arriving at the maximum benefit to the motoring public. Some of these factors are the differences in mechanical conditions and types of vehicles, the differences in ability and temperament of drivers, the variation in light conditions, the speed differential of the vehicles in question, and the many physical differences in the road itself.

Most motorists exercise good judgment in refraining from overtaking and passing a vehicle when sight distance appears to be inadequate. To actually indicate by pavement marking and post mounted signs the length of a restriction probably adds to the convenience of a motorist and relieves him of some of the responsibility of exercising his own judgment at the locations so marked. This transfer of judgment necessarily places the responsibility upon the public authority having jurisdiction. Consequently, the establishment of such zones creates two problems---one, when passing should not be permitted, and the other when it should be allowed as inferred by the termination of the restrictive marking. Both phases of this problem have been taken into account in the development of this study.

Pavement markings are closely allied to signs. They are extremely helpful in safeguarding and expediting the movement of traffic. Particularly are they valuable for night driving and during unfavorable weather conditions. A national standard method of marking sections of highway with no-passing zones where it is unsafe to make a passing maneuver would enhance safety considerably.

The writer has long felt the need for a complete study of the subject presented in a concise form for study by Highway Engineers and students in Civil Engineering in the various universities. It is hoped that the proposed study will be of value (especially to engineering students), and that the nonuniformity and confusion will soon be eliminated. To aid in the establishment of standardization and uniformity of the marking and signing no-passing zones, and to aid the student in Highway Engineering, this study has been prepared.

NO-PASSING ZONES IN OPPOSITE DIRECTION

The establishment of a no-passing zone is desirable when a sufficient length of road ahead is not visible to permit overtaking and passing another vehicle safely. Modern design practice on all classes of the primary highway system becomes necessary. However, a major portion of the existing milage having been constructed under design policies now considered obsolete, many locations may be found where the sight distance limited by vertical and horizontal alignment warrants passing restrictions.

Ability to see ahead is of the utmost importance in the safe and efficient operation of a highway transportation system. The path and speed of motor vehicles are subject to the control of drivers whose training in many cases is elementary. If safety is to be built into highways to the extent possible, it is vitally necessary that the road, at all points, be opened up to view for a sufficient distance to enable the driver to so control the speed of the vehicle as to avoid striking unexpected obstacles in its path, and, at frequent intervals, the road should be opened to view for a sufficient distance to enable the driver to pass overtaken vehicles without hazard.

Passing of overtaken vehicles on two and three-lane roads is accomplished by using a traffic lane which may be occupied by a vehicle traveling in the opposite direction. It is desirable that a sufficient length of road be visible at every point to permit passing with safety, but in practice this rarely is economically possible. Many drivers are incapable of judging when the sight distance is insufficient for passing with safety, so that it is necessary to provide warnings at all such locations.

The sight distance ahead on a road generally is not the same as the sight distance to the rear. If a stripe indicating a no-passing zone does not differentiate between opposing directions of travel, such as a single stripe on the center line, the usefulness of the road is seriously impaired and a disrespect for restrictive stripes may be developed by the motoring traffic.

A no-passing zone for traffic in one direction may overlap a no-passing zone for traffic in the opposite direction or there may be a gap between the ends of the zones. A system of striping which differentiates between traffic in opposing directions naturally will show these overlaps and gaps. A broken stripe with a continuous stripe alongside to indicate a no-passing zone would have a continuous stripe on both sides where the no-passing zones overlap on a two-lane road.

Passing on three-lane roads is accomplished on the middle lane. If the system of marking at no-passing zones restricts traffic in both directions from passing, the middle lane becomes ineffective. Most of the middle lane, however, can be used effectively; confusion can be avoided, hazard diminished, and utility of the road increased by a system of striping which restricts traffic in one direction to one lane but permits traffic in the opposing direction to use two lanes.

There has been some question regarding the most desirable type of operation over the crest of a hill on three-lane roads. Some engineers contend that the delay caused by slow moving trucks going uphill should be avoided by providing two lanes for upgrade traffic. From the standpoint of sight distance this system is hazardous in that it encourages passing when the sight distance is limited. Traffic should be confined to the right lane when sight distance is inadequate for passing just as on two-lane roads. When the road ahead opens up to view, the restrictions should be terminated and passing permitted on the middle lane.

Diagonal striping should be provided in the middle lane, crossing from the left lane line to the beginning of the restrictive striping on the right lane line. The diagonal striping should meet the longitudinal restrictive striping at the beginning of the no-passing zone. The diagonal striping should inform drivers in one direction of the necessity of moving over to the right lane without crossing the diagonal striping but should not prevent crossing by vehicles traveling in the opposite direction.

Where traffic density is such that safe passing sections lose their usefulness due to the fact that passing lanes generally are occupied by opposing traffic, vehicle drivers cannot pass and are required to reduce speed for long periods of time. Inability to pass indicates that the traffic density is greater than the capacity of the road at the assumed design speed and a wider road is required. Some increase in capacity may be obtained by adding a third lane at safe passing sections on a two-lane highway. The extra lane should be at least as long as the minimum length of safe passing sections for three-lane highways and preferably should be as long as the safe passing section where heavy traffic makes it probable that the opposing lane, normally used for passing, will be occupied.

An extra lane added to a three-lane highway creates a four-lane section. The added lane should be as long as the safe passing section since passing must be completed before reaching the end of the section. Otherwise the middle lane beyond the section, where sight distance is inadequate for passing, may have to be utilized for completing the passing maneuver.

The addition of two lanes at a safe passing section on a two-lane highway to form a four-lane section serves to reduce the passing minimum sight distance to that required for a three-lane safe passing section. The theoretical minimum length of such passing section is the distance traversed by the passing vehicle only, whereas on a two-lane highway the distance traversed by opposing traffic must be considered also. Topographic conditions sometimes may make the construction of a four-lane passing section with shorter sight distance preferable to the construction of a standard two-lane section with longer sight distance.

A four-lane safe passing section on a two or three-lane highway is dangerous on account of the natural tendency of a driver to assume that it is safe to pass another vehicle at any time as long as it is possible to keep his vehicle near the end of a four-lane safe passing section resulting in crowding at the point where the lanes converge to two or three lanes.

A third lane constructed on the upgrade side of a long, steep grade on a two-lane highway often serves a useful purpose in that vehicles such as trucks which are retarded considerably by grade may use the extra lane to permit overtaking vehicles to pass. The length of the extra lane need not be fixed according to any specified rules nor is it necessary that it be constructed with sight distance greater than the no-passing minimum, but it is advisable to construct it as long and with as great sight distance as possible. The effectiveness of the extra lane on a grade is increased when it extends to the point where a retarded vehicle may resume nearly normal speed before returning to the normal lane, but it is necessary that the point of constriction be visible for an appreciable distance. Downhill traffic should be discouraged from using the normal uphill lane as a passing lane.

It is desirable that vehicles on two and three-lane roads approaching an intersection keep to the right and that all passing maneuvers should be completed before reaching the intersection. Passing while crossing an intersection is hazardous because (1) the passed vehicle may obstruct the view of the crossroad to the right, (2) the passed vehicle may turn left in front of the passing vehicle, and (3) the driver of a passing vehicle may find it difficult to observe crossing and turning traffic at the same time that he is required to watch traffic passing for some distance each side of an intersection. Once beyond an intersection, there is no further need to restrict passing if sight distance and traffic conditions permit passing. The stripe, therefore, should restrict vehicles from passing approaching the intersection and not restrict passing beyond the intersection.

When one road at an intersection is stopped at the intersection, the use of restrictive striping on the preference road is open to serious question. There is some hazard in the possibility of a left-turning vehicle cutting in front of a passing vehicle but the hazard due to possible restriction of sight is nil. It appears to be inadvisable, therefore, to restrict the free movement of traffic on the preference road by the use of no-passing marking if not required otherwise.

Traffic should be restricted from passing while crossing a railroad at grade. While there is no left-turning traffic, the passing vehicle may obstruct the view of the signal and the track to the right. A restrictive stripe also has the desirable effect of lining up vehicles in the right lane when the crossing is closed so that traffic is free to move in both directions when the intersection is clear.

Normally the driver of a passing vehicle should return to the right lane before reaching the beginning of a restrictive stripe. The length of restrictive stripe at the approach to an intersection, therefore, is theoretically zero. The restrictive stripe should, however, be visible for some distance so that it is necessary to make it an arbitrary length, say 100 to 200 feet. An appreciable length of restrictive stripe will also have the desirable effect of encouraging drivers, who normally return to the right lane before reaching the intersection.

Where vehicles are stopped at an intersection by a traffic light, STOP sign or preference road sign,or, in the absence of such controls, are frequently stopped by traffic, it is desirable that vehicles facing the intersection, line up on the right so that traffic is free to move in both directions when permitted. The restrictive stripe encourages the lining up of vehicles under such circumstances and its length may be determined by the probable number of vehicles which will be stored, allowing about 20 feet for each vehicle.

A restrictive stripe on a three-lane road approaching an intersection normally should be located on the right lane line in the same manner as used at a location with short sight distance. This method lines up vehicles approaching the intersection and permits passing by vehicles leaving the intersection. Where vehicles are likely to be stopped, however, it may be desirable to locate the stripe on the center line of pavement. If stopping is effected by continuous traffic light control it may be desirable to limit striping to normal lane lines and omit restrictive stripes altogether. Passing may be accomplished when the light is green if sight distance and traffic conditions for storage when the light is red is adequate. If traffic is evenly divided in both directions, opposing traffic in the middle lane will have to free itself on the GO signal. When traffic is heavy, however, it generally is unbalanced and the omission of restrictive stripes may have the desirable effect of providing two lanes for storage and movement in one direction. At important intersections three-lane roads may be widened to four lanes and a restrictive stripe placed at the center line.

Where a considerable density of left-turning traffic is expected it may be desirable to omit the restrictive stripe and mark the middle lane on the approaches to an intersection for the exclusive use of left-turning vehicles.

In striping a highway to restrict passing of vehicles where sight distance is inadequate the general concept in choosing factors is totally different from that in choosing factors for designing a highway. If the same factors are chosen and a highway is striped to restrict passing wherever the sight distance is less than the passing minimum, and almost all drivers accept the dictum that they are required to keep to the right of a restrictive stripe throughout its length, the use of the highway is severely impaired. The passing minimum sight distance used in design includes a distance traversed during perception time. This distance should not be included in the length of restrictive stripe because a driver sees the beginning of a stripe for some distance, giving him ample time in which to size up a situation. The passing minimum sight distance used in design also includes a distance required to pass a slower moving vehicle. If this distance is striped for no-passing, the only distance available for passing is that in excess of the passing minimum. This situation may be avoided by using a type of stripe which is not restrictive but conveys the thought that a passing maneuver should not be begun within its limits, but if begun before reaching the beginning of the stripe may be completed farther ahead, provided, of course, opposing traffic does not come into view before the passing maneuver is begun. While it is possible to differentiate between a restrictive stripe and one of the character described, the thought which must be conveyed is too complicated for many drivers and should not be considered for modern traffic.

Even if it were possible to convey the proper thought to all drivers, striping based on the passing minimum would restrict the use of a road unduly, even though distance traveled during perception time is deducted from the passing minimum distance. The distances used in design are based on the delayed passing of a vehicle traveling 10 mph less than the assumed design speed of the road in the face of opposing traffic traveling at the assumed design speed. If striped in accordance with these assumptions, passing would be restricted when it could frequently be accomplished with safety under one or more of the three following conditions: (1) the passing vehicle may not be delayed or slowed down to the speed of the overtaken vehicle. If the opposing lane is clear the overtaking vehicle may pass at a higher speed, reducing the time and distance of passing; (2) the overtaken vehicle may be traveling at a speed slower than 10 mph less than the assumed design speed of the road. The average speed of travel, particularly on 60 or 70 mph roads, is slower than 10 mph less than the assumed design speed and overtaken vehicles are likely to be traveling at speeds less than average; and (3) the opposing vehicle which appears after the passing maneuver has begun may be traveling slower than the assumed design speed of the road. It is more likely to be traveling at the average speed.

SIGHT DISTANCE AT NO-PASSING ZONES

Sight distance is the length of highway ahead visible to the driver. When not long enough to permit safe passing of overtaken vehicles it may be termed non-passing sight distance. The minimum non-passing sight distance should be long enough to permit a vehicle traveling at the assumed design speed of the highway to stop before reaching a stationary object in the same lane. Sight distance at every point on a highway should be as long as possible but at no point should it be less than the non-passing minimum sight distance.

The non-passing minimum sight distance is the sum of two distances; one, the distance traversed by a vehicle from the instant the stationary object is visible to the instant the brakes are applied, and the other, the distance required to stop a vehicle after the brakes are applied. The first of these two distances depends upon the speed of the vehicle and the sum of perception time and brake reaction time of the operator. The second distance depends upon the speed of the vehicle, the characteristics and condition of brakes, tires, and pavement surface, and the alignment and grade of the highway.

Many tests have been made to determine the brake reaction time of motor vehicle operators, that is, the time required to apply brakes. The average brake reaction time is about one-half second and occasionally requires a full second or more. For safety a reaction time that is sufficient for most operators, rather than for the average operator, should be used in any determination of minimum sight distance. A brake reaction time of a full second, therefore, is assumed.

Few tests have been made to determine perception time, in this case the time required for motor vehicle operators to come to the realization that the brakes must be applied, or the time lapsing from the instant the stationary object is visible to the instant the operator realizes that the object is stationary. Under certain conditions operators come to this realization almost instantly. Among those conditions are disable vehicles with persons on the ground adjacent thereto, flares at night, and wigwagging flashlights at night. Under most conditions the operator must learn by subconscious association with adjacent stationary objects such as fences, trees, guardrails, etc., that the object is stationary. This takes time. The amount of perception time varies considerably, depending upon the distance to the object, the natural rapidity with which the operator reacts, the optical ability of the operator, atmospheric visibility, type and condition of roadway, type, color, and condition of hazard, etc. At higher speeds perception time probably is less than at lower speeds due to the fact that drivers generally are more alert. On the other hand, the longer distances associated with higher speeds may require more time due to the greater difficulty of seeing and the uncertainties involved.

Since perception time depends upon the discrimination of the driver, it probably is greater than brake reaction time.

The minimum value which is more than that required by most motor vehicle operators is assumed to vary from two seconds for a speed of 30 mph to one second at 70 mph. These assumptions are subject to verification or change when perception time of this character has been determined by exhaustive, scientifically controlled tests under various conditions.

The report of the Massachusetts Highway Accident Survey, made in 1934 under the direction of the Massachusetts Institute or Technology, records the results of tests for reaction time in which the stop light of the forward car was the signal to the driver of the rear car and inattention was eliminated from the tests. One hundred and eighty individuals made 2,245 tests. The average reaction time was 0.64 seconds; 5 percent of the observations were in excess of 1.0 second; 20 percent of the drivers occasionally required at least 1.0 second.

The approximate braking distance of a vehicle on a level highway may be determined by the use of the formula

$$d \text{ equals } v^2 / 2fg$$

in which d is the braking distance in feet, v the velocity of the vehicle in feet per second when the brakes are applied, f the coefficient of friction between tires and roadway, and g the acceleration of gravity. Changing v in feet per second to V in miles per hour and substituting 32.2 for g, the formula becomes

$$d \text{ equals } V^2 / 30f$$

It is assumed that the friction force is uniform throughout the period of deceleration. This is not strictly true since the coefficient of friction increases slightly as the velocity of the vehicle decreases so that the braking distance varies as some power of the velocity greater than the square. For any one set of conditions the use of a uniform friction factor is fully justified because of the method employed by many in the determination of coefficients of friction. In this method measurements of the distances required to stop a vehicle traveling at known velocities by the application of brakes are made and coefficients of friction are computed by the use of the formula based on a uniform coefficient of friction.

Rough tests made by the Massachusetts Highway Accident Survey in 1934 under the direction of the Massachusetts Institute of Technologh indicated that the coefficient of friction is not the same for all speeds and that if the braking takes an appreciable length of time the friction factor seems to decrease, resulting in decreased deceleration toward the end of the braking period. While the tests were not extensive or precise, there was some indication that with constant braking pressure the braking distance varies as some power of the velocity greater than 2, possibly 2.3. In other words, if trends are projected into the future and higher vehicle speeds thought of, a conservative value of the coefficient of friction should be adopted in any investigation into required sight distance in order to allow to some extent for this phenomenon. It may be pointed out, however, that the average driver increases brake pressure as the braking operation progresses, particularly if it appears to him that he is approachingthe hazard too rapidly.

The coefficient of friction varies considerably and depends on many physical conditions such as condition and air pressure of tires, type and condition of the surface of the pavement, the presence of moisture, mud, snow or ice, etc. Tests made by R. A. Moyer on clean wet pavement of various types resulted in coefficients of friction for skidding straight ahead varying from 0.6 to 0.8 at 10 mph and 0.4 to 0.6 at 40 mph. Lower values for speeds greater than 40 mph should be expected but there is a definite flattening out of the curves with an increase in speed. Improvements in the skid resistance of tires and road surfaces also may be expected. The friction factors for skidding are assumed to vary from 0.62 at 30 mph to 0.5 at 70 mph. A factor of safety of 1.25 is applied to allow for the many variations in vehicles, surfaces, conditions, and drivers, resulting in assumed safe coefficients of friction varying from 0.5 at 30 mph to 0.4 at 70 mph. Higher factors are not considered safe. Many of the tests resulted in only slightly higher friction factors for skidding.

The assumed factors also result in decelerations which are just within the rate considered comfortable for most passengers. Bureau of Standards tests indicate a rate of deceleration of 16.1 feet per second per second as the maximum for comfort. This is equivalent to a coefficient of friction of 0.5. The Motor Vehicle Department of the State of New Jersey assumes as a comfortable rate of deceleration 17.4 feet per second per second which is equivalent to a coefficient of friction of 0.54.

The sum of the distance traversed during perception and brake reaction time and the distance required to stop the vehicle is the safe stopping distance and, therefore, the minimum non-passing sight distance.

When a highway is on a grade the formula for braking distance is modified to result in the following:

d equals V / 30 (f $\pm$ grade)

in which "grade" is the percent of grade divided by 100. The safe stopping distances on upgrades are shorter and downgrades longer.

It is evident that grades up to 3 or 4 percent for all speeds and grades up to 8 or 9 percent for the lower speeds may be ignored as regards their effect on the non-passing minimum sight distance. Where the unusual combination of speed grade and high speed occurs the effect of grade on the stopping distance may be recognized and the non-passing minimum sight distance adjusted. Downgrades control on all undivided highways since each upgrade constitutes a downgrade in the opposite direction.

On two-lane two-way highways, which constitute the bulk of our highway system, fast-moving vehicles frequently overtake slow-moving vehicles. Passing must be accomplished on a lane that may be occupied by opposing traffic. If passing is to be accomplished with safety the driver of the passing vehicle must see enough of the highway clear of opposing traffic so that if vehicles appear after he has started to pass he will have sufficient time to pass and return to the right lane without cutting off the passed vehicle and before meeting opposing traffic. If sight distance is inadequate to permit passing with safety most drivers generally choose to reduce speed and remain behind the slow-moving vehicle until sufficient clear vision is available to offer a safe opportunity to pass. If the opposing lane is clear of traffic beyond a limited visible section of highway, drivers have no means of knowing it. In effect they are avoiding phantom traffic under such conditions.

Mile after mile of highways with sight distance inadequate for safe passing are hazardous and inefficient. They are hazardous because they tend to encourage even the patient and careful driver to take a chance, especially after remaining behind a slow-moving vehicle or train of vehicles for one curve after another without encountering opposing traffic and realizing that passing could have been accomplished. They are inefficient because they materially reduce the capacity of the highway at the assumed design speed unless traffic is light or free of slow-moving vehicles.

Highways on which passing must be accomplished on lanes that may be occupied by opposing traffic can be made less hazardous and more efficient if sections with sight distance safe for passing are provided at frequent intervals. On such highways impatient drivers are encouraged to remain behind slow-moving vehicles until they see a length of highway clear of opposing traffic sufficient for passing and traffic at the assumed design speed is given frequent opportunities to safely pass slower-moving vehicles.

While it is desirable to construct highways on which adequate sight distance for safe passing is encountered at all places, the limitations of topography and right of way make it economically inadvisable to do so. It is not absolutely necessary that every horizontal and vertical curve be designed with adequate sight distance for safe passing, but if safe driving is to be encouraged and free movement of traffic made possible it is essential that sections of highway on which a driver sees enough of the highway to know whether or not it is safe to pass slower-moving vehicles are encountered frequently. The great majority of drivers will not pass slower-moving vehicles at points of danger if they believe that a section of highway where the vehicles may be passed with safety will be reached in a short time.

On the basis of the foregoing, highways on which passing must be accomplished on lanes which may be occupied by opposing traffic should be designed using two minimum sight distances; one sufficient for the passing of vehicles with safety and the other a non-passing minimum.

Sight distance adequate for passing with safety should be encountered at frequent intervals on two-lane highways, the interval depending principally upon the topography, the assumed design speed of the highway, and the probable future density of traffic. If the expected future traffic is great enough to utilize the full capacity of the highway, vehicles will be overtaken frequently. Sections with sufficient sight distance to enable overtaking vehicles to pass slower-moving vehicles with safety preferably should be located so that the distance between the end and beginning of adjacent safe passing sections will be not more than a mile. If the overtaking vehicle is compelled to travel at 30 miles per hour, a mile represents a time interval of two minutes. If opposing traffic prevents passing at one or two successive sections the time interval is more than doubled or tripled. Light traffic density reduces the probability of encountering opposing traffic at a safe passing section so that the distance between sections may be greater than a mile, but the distance between safe passing sections should not be greater than about two miles.

The probable speed of overtaken vehicles affects the spacing of safe passing sections. On most two-lane highways the speed of overtaken vehicles cannot be estimated with any degree of precision, but on many highways which form regular routes for slow-moving trucks, a fair estimate of the speed may be made. Very slow-moving vehicles require closer spacing of safe passing sections if the patience of vehicle operators is not to be overtaxed.

Where highways are designed with the use of one minimum sight distance, sections with sight distance considerably greater than the minimum generally are constructed. These sections, however, accidentally result from locating the highway to meet topographic conditions. They may or may not be long enough to permit passing with safety and the distance between them may or may not be short enough to encourage drivers to confine attempts to passing to these sections. In the design of two and three-lane highways, sections safe for passing should be given conscientious thought and they should not come about only as accidental results of fitting the highways to the topography.

Uniform spacing of safe passing sections is unnecessary. In general the sections should be close enough to encourage drivers to confine attempts to pass to these sections. A distance of one to two miles between safe passing sections should be adopted and the designer should be given considerable leeway in utilizing favorable topographic conditions in locating safe passing sections with the spacing as close to the one adopted as possible.

When computing passing minimum sight distances a wide choice of assumptions for traffic behavior is presented. Assumptions which result in longer sight distances should be chosen if the resulting sight distances are to be safe minimums. On the other hand, to justify expenditures for providing the resulting minimum sight distances, the assumed actions should be those that are practiced frequently by an appreciable percentage of drivers.

The assumed actions of drivers on two-lane highways are as follows:

(a) The overtaken vehicle travels at uniform speed.

(b) The passing vehicle is forced to travel at the same speed as the overtaken vehicle while traversing the section of highway with sight distance unsafe for passing.

(c) When the safe passing section is reached and the road opens up to view, the driver of the passing vehicle requires a short period of time (perception time) to look over the situation, watch for opposing traffic, and decide whether or not it is safe to pass.

(d) Passing is accomplished by accelerating during the entire operation.

(e) Opposing traffic appears the instant the maneuver of passing begins and arrives alongside the passing vehicle just as the maneuver is completed.

Passing often is accomplished in shorter distances than those resulting from the above actions by lagging behind the overtaken vehicle and, as soon as the road opens up to view, accelerating in the right lane before turning out to pass. In effect acceleration is partially accomplished during perception time so that the passing maneuver is begun at a higher speed. This action should not be assumed in design, however, as it results in sight distances too short for safe passing by the assumed method which is used naturally by many drivers and frequently is forced on all drivers by the presence of opposing traffic.

Another method of passing in a shorter distance is one in which the overtaken vehicle does not slow down but continues at a higher speed and passes the slower-moving vehicle.

This operation is possible only if the slower-moving vehicle is overtaken at a point where the road is open to view for a considerable distance and the opposing lane is clear. Obviously this method need not be considered in computing passing minimum sight distances.

Many vehicle drivers accelerate only at the beginning of the operation of passing, continuing at a uniform speed as soon as an appreciably higher speed is reached. Passing minimum sight distance for two-lane highways includes the distance traversed by an opposing vehicle coming into view as soon as passing is begun. In the face of opposing traffic, few drivers refrain from continuing to accelerate and returning to the right lane as quickly as possible. It is assumed, therefore, that the passing vehicle will accelerate throughout the maneuver.

The passing minimum sight distance for two-lane highways is the sum of three distances:

(a) Distance traversed during perception time.

(b) Distance traversed by passing vehicle while passing.

(c) Distance traversed by an opposing vehicle during the operation of passing.

While attempts sometimes are made to pass vehicles traveling at speeds nearly equal to the assumed design speed of the highway, it is economically inadvisable to make extra expenditures to accommodate driving of this character. To accommodate the passing of vehicles traveling at a rate within 10 mph of the assumed design speed does not appear to be justified and it is doubtful if accommodations should be provided for the passing of vehicles traveling at a rate within 15 miles per hour of the assumed design speed. For informational purposes calculations are made for passing vehicles traveling at 10, 15, 20, and 25 miles per hour less than the assumed design speed.

Trains of vehicles of two or more are encountered frequently. Generally, however, they are traveling at speeds considerably less than the assumed design speed of the highway and may not require a greater passing distance than that required to pass one vehicle traveling at only 10 or 15 miles per hour less than the assumed design speed. For informational purposes calculations are made for passing a train of two vehicles as well as passing one vehicle.

The probable spacing of vehicles at various speeds is an important factor affecting the minimum sight distance required to pass with safety. When vehicles are moving at the same speed in the same direction in one traffic lane the spacing of vehicles should be such that if one vehicle operator applies his brakes the operator of the vehicle behind will have sufficient time to do likewise and avoid collision. The average brake reaction time of most drivers has been found to be about one-half second. The perception time, in this case the time required for the operator of the rear vehicle to come to the realization that the vehicle ahead of him is slowing down, has not been determined accurately and probably varies considerably. If the forward vehicle is equipped with a brake actuated rear signal and the driver of the rear vehicle naturally reacts quickly, the perception time will probably be very small. A perception time of one-half second is assumed, making the total of perception and brake reaction time one second.

In 1927 the Maryland State Roads Commission made an aerial traffic survey of the Baltimore-Washington Road, then a two-lane highway. The manner of making the survey made it possible to observe the spacing of vehicles at various speeds. The observations indicated that the clearance between vehicles varied as the 1.3 power of the velocity and may be represented by $0.5\ V^{1.3}$ in feet when V is the velocity in miles per hour. The actual observed spacing of vehicles therefore was:

S equals $0.5\ V^{1.3}$ x 17

In 1933 Dr. Bruce D. Greenshields used a moving picture camera in observing the behavior of traffic and found the following expression for the spacing of cars where speed is controlled by that of the leading car of a group:

S equals 1.1 V x 21

in which S is the spacing in feet and V the velocity in miles per hour.

The rate of vehicle acceleration may vary considerably, depending upon the driving ability and habits of the operator and the mechanical possibilities and condition of a particular vehicle.

In determining passing minimum sight distance it is assumed that passing, once begun, is done in the face of opposing traffic. Under such circumstances most drivers accelerate as rapidly as possible.

It is assumed that the maneuver of passing is begun at the speed of the overtaken vehicle and completed at a much higher speed. The rate of acceleration therefore is higher at the beginning of the maneuver than at the end.

It is assumed that opposing traffic travels at the assumed design speed. It is unreasonable to make provision for the small percentage of drivers who will travel at greater speed.

The passing lane on a two-lane highway normally is used by opposing traffic. The passing lane on a three-lane highway is the middle lane which normally is used only by passing traffic in either direction. Passing drivers generally are looking for vehicles in the opposite direction and are more alert than drivers who are on the right side of a two-lane road. In addition a hazardous situation confronting opposing drivers in the middle lane of a three-lane highway is more easily met than one on a two-lane highway because collision on a three-lane highway can be avoided by either driver returning to the right lane whereas on a two-lane highway the passing driver alone can avoid collision in this manner. Another safety factor on a three-lane highway is the fact that four passenger cars can pass on the normal width of pavement in an emergency. Therefore, the sight distance required for safe passing on a three-lane highway is less than that required on a two-lane highway.

There is little likelihood that three-lane highways will be constructed in topography which ordinarily limits the design speed to 30 or 40 miles per hour. Traffic justifying the construction of a three-lane highway generally warrants extra expenditure for increased design speed or for four-lane width or both.

Three-lane highways should be constructed with safe passing sections much closer together than on two-lane highways. The middle lane is accepted generally as a passing lane and most drivers rightfully assume that it is safe for passing if it is free of opposing traffic for the visible length of highway. Sections unsafe for passing are marked for two-lane operation. If these sections are long and occur frequently the topography is unsuited for three-lane construction. The capacity of three-lane roads under such circumstances is not much greater than of a two-lane highway. As traffic approaches the capacity of a three-lane highway the highway should be safe for passing at practically every point or a four-lane highway is required.

Appreciable grades on safe passing sections increase the sight distance required for safe passing. Passing is easier apparently for the vehicle traveling downgrade due to the fact that the overtaking vehicle may accelerate rapidly and thus reduce the time of passing. However, the overtaken vehicle may also accelerate rapidly so that a dangerous situation akin to a race may result.

The sight distances required to permit vehicles traveling upgrade to pass with safety are greater than those required on level roads due to two factors; the acceleration of the overtaking vehicle is reduced, increasing the distance traveled by it. If, for example, it is assumed that the grade on a highway designed for 50 miles per hour decreases the acceleration of the overtaking vehicle from 1.7 to 1.2 miles per hour per second and increases the speed of opposing traffic to five miles per hour greater than the assumed design speed, the theoretical minimum sight distance required to pass one vehicle with safety is increased about 270 feet or 17 percent.

Passing vehicles by crossing the center line of four-lane undivided highways or crossing the median strip of four-lane divided highways is not only reckless but rarely necessary. Opportunities for passing within the limits of half the road present themselves frequently unless the capacity of the road is severely taxed. There is no necessity, therefore, for providing sections of highway in which the sight distance is sufficient for a vehicle to safely pass another vehicle by using a lane provided for opposing traffic.

A four-lane highway, therefore, should be so designed that the sight distance encountered at all points on the highway is greater than the non-passing minimum.

The eyes of the average driver in a private automobile are about 4½ feet above the pavement. The eyes of the drivers of some low-hung makes of automobiles are somewhat lower. Those of drivers of busses and trucks are considerably higher. It is assumed, therefore, that the eyes of the driver are $4\frac{1}{2}$ feet above the pavement.

Non-passing minimum sight distance is based upon safe stopping distance or the distance required to stop from the instant a stationary object in the same lane becomes visible. The stationary object may be a vehicle or some other high object, but it may be a very low object such as merchandise dropped from a truck or small rocks from side cuts. To be on the safe side the surface of the pavement should be visible to the driver for the entire length of the non-passing sight distance, but the necessity for it is questionable. Large holes rarely are encountered in modern pavements and very small objects generally can be avoided without the necessity for stopping. Therefore, a height of object of 4 inches is assumed in determining non-passing sight distance.

Vehicles are the objects that must be seen when passing. It is assumed, therefore, that the height of object for passing sight distance is $4\frac{1}{2}$ feet, the same as the height of eye. The top of the average closed body type automobile is somewhat more than $4\frac{1}{2}$ feet above the pavement and the tops of busses and trucks are considerably higher. The few open body types that are in use do not influence the choice of the height of object. While the headlights of a vehicle are only about 2 feet above the pavement a reduction in the value of the assumed height of object is not necessary. In the case of sight distance for safe passing at night the beams of the headlights come into view and even before the top of a vehicle can be seen at the same location in the daytime.

In the case of the tail light no advance notice of its presence, similar to the beam of a headlight, is given. It may be, however, that in the not very distant future tail lights will be placed near the tops of vehicles instead of where they now are located. The present position of the tail light is a relic of the days when open body types of automobiles were common and it was necessary to place the tail light below the level of the top in its folded back position. A tail light at the top of the vehicle normally is just as visible as one at a low level and is less likely to be spattered with mud. It is not in the way of trunks and rear spare tires. It is not so likely to be hidden by persons standing or working in back of the vehicle. Such obstruction has caused numerous serious rear end collisions.

If tail lights are not elevated, auxiliary lights at the tops of passenger vehicles may come into general use. Many passenger vehicles already are equipped with lights indicating the sides of the vehicle and when their safety value is appreciated lights near the top of the body-front and rear may be used by most vehicles much in the manner that lights of this character are in use on practically all trucks and busses. At but small additional cost passenger vehicles can be equipped with high auxiliary lights that will have the effect of increasing night sight distance over the crests of hills by appreciable amounts.

The design of a highway is greatly influenced and often determined by the standards for minimum sight distance. Frequently other factors considered in the preliminary design are more important. Under such circumstances sight distance is measured after the preliminary plans are drawn and the design adjusted where necessary. Regardless of the method used in design, tables or charts that show the relation between sight distance and other factors, such as grades and vertical curves,are useful in guiding the designer.

It seems practical to measure inclined and horizontal sight distance independently of one another. The minimum sight distance at any point is the smaller of these distances.

Charts showing the relation between the sight distance over the crest of a vertical curve, the length of vertical curve, and the difference in grades of the approaches are useful in designing vertical curves to meet sight distance requirements and in determining sight distance when the other factors are known.

Horizontal sight distance may be scaled from the plans. In this method the lengths of circular curves and other alignment characteristics do not affect the accuracy of the result. The locations of buildings, fences, hedges, rows of trees, high ground, and other topographic features generally are measured and plotted when they are on the right of way. They should also be measured and plotted when they are located off the right of way when there is a possibility that they will obstruct the line of sight on the proposed highway.

The effect of a cut on the inside of a curve may be determined graphically. The obstruction may be shown on the work sheets by a line representing the proposed excavation slope at a point $4\frac{1}{2}$ feet above center line grade. This line generally is parallel to the center line and the distance from it may be determined from the standard cross section. The line terminates where existing ground is $4\frac{1}{2}$ feet above center line grade.

Where the section of highway within the limits of the proposed line of sight is on a uniform grade this line at a height of $4\frac{1}{2}$ feet delineates the obstruction accurately for passing sight distance and closely for non-passing sight distance. Changes of grade coincident with horizontal curves should be discouraged but where there is a change of grade within the limits of the proposed line of sight, the line of sight for the longest possible sight distance, in the case of a summit, meets the excavation slope at a lower level and therefore farther from the center line. Generally this may be ignored without appreciable error.

Sight distances less than 1000 feet may be scaled to the nearest 50 feet and those greater than 1000 feet may be scaled to the nearest 100 feet. They may be scaled between points on the center line instead of between points on the traffic lane with little error.

Sight distance should be recorded on plans for highway improvements or construction in such manner that they may be read at a glance. A simple record in which the sight distances in both directions are recorded by arrows and figures at each station is effective and takes up little space. The record may be placed just below the profile or just above the profile section when standard plan and profile sheets are used. Little work is required in placing sight distances on the plans after they are known.

Sight distances less than the minimum for non-passing sections may be underscored. Sight distances greater than the minimum for a safe passing section may be recorded as than minimum. Some work may be avoided at long sections of a highway in which the sight distances are greater than the minimum by recording the minimum at the beginning and end of such sections or both ends of the sheet.

Sections of highway on which the sight distances at each end toward the center of the section are at least the minimum for safe passing may be recognized as safe passing sections. Where small scale plans and profiles or small scale plans for sheet index purposes are placed on the title sheet or elsewhere, safe passing sections may be recorded by long double-headed arrows just below the profile or alongside the plan. Safe passing sections and the distances between them can be read at a glance.

Passing of overtaken vehicles on two and three-lane roads frequently may be accomplished when the sight distance is considerably less than the minimum passing sight distance developed herein. The speed of the overtaken vehicle may not be within 10 miles per hour of the assumed design speed for the road, the passing vehicle may not be required to slow down before leaving the right lane to pass, and opposing vehicles may not appear or may be traveling slower than the assumed design speed for the road. Any one or more of these conditions makes it possible to pass when the sight distance is less than the minimum passing sight distance but the danger increases as the sight distance decreases.

The sight distance at every point on a highway should be as great as possible. Where sight distance sufficient for passing with safety cannot be obtained the sight distance should in no case be less than the non-passing minimum and preferably should be increased above the non-passing minimum as much as is economically feasible. As the sight distance increases restriction to passing decreases because vehicles moving at higher speeds may be passed, making it possible to pass a greater percentage of them. This has the desirable effect of reducing the bunching of traffic caused by sections of road with sight distance insufficient for passing with safety. It may also have the undesirable effect of encouraging passing when it is unsafe to do so. Where funds are limited it may be desirable, therefore, to make expenditures for safe passing sections at frequent intervals instead of increasing sight distance at critical points where the sight distance already is greater than the non-passing minimum.

No-passing zones on an existing road are evaluated by determining the design speed of the road or section of road, after which the beginning and end of each no-passing zone are located. The sight distance at these points corresponds to the minimum passing sight distance for purpose of marking pavements.

WARNING SIGNS

Warning signs, as the name indicates, are used for the purpose of advising drivers concerning the existance of hazardous conditions on or adjacent to the road itself. Adequate warning signs are of great assistance to the driver of a motor vehicle, and are a valuable means of safe-guarding and expediting traffic. The use of such signs, however, should be kept to a minimum consistent with a satisfactory degree of safety. The promiscuous use of these signs tends to create a disregard for them.

The location and installation of signs becomes more important each year. Higher speeds require visibility at greater distances, and wider roadways mean that the signs be set further from the center of such roadways. Recently there has been a widespread move to erect larger and more conspicuous signs of all types, with the result that the motorist is given adequate warning before arriving at the point of danger.

Striping and marking of roadways and objects adjacent to said roadways can be effectively used to convey warning and guidance information. These can be used separately or in conjunction with signs. The proper and judicious application of these markings and center lines can be extremely helpful in safeguarding and expediting the movement of traffic. No-passing zones are determined by a study of the road or section of road to be treated, after which the beginning and end of each passing zone are located.

Traffic signs are primarily intended for the benefit of the motorist who is unacquainted with the road. For this reason the warrant determination and the installation of signs should be well standardized so that any one sign will always convey the same meaning and will always be located the same with respect to the hazard or condition described. This study attempts to set forth definite specifications for the warrant and location of all signs. It must be realized, however, that it would be impossible to make specifications which could be applied to all cases and that the value of signs depends to a great extent on the good judgment of the person making the installation. Signs should always be placed so as to obtain the maximum efficiency.

All signs, if complied with, cause the motorist a certain amount of inconvenience. If any sign is installed which, in the opinion of the motorist, has too great an inconvenience factor with respect to the hazard or regulation described, then his future tendencies will be toward non-compliance. Therefore, for any given condition, the sign with the lowest inconvenience factor which will accomplish the desired results should be used.

Modern highway speeds and complex intersections make it imperative that signs can be seen from long distances and understood almost immediately. Standardization helps to make this possible. A color-blind person may receive a sign message by means of shape, text of symbol, while a person who cannot read may receive the same message by means of shape, color, and symbol. In order to obtain complete standardization of signs it is necessary that their application also be uniform. Identical conditions shall always receive the same treatment so far as signs and their applications are concerned.

If a sign is of any importance during daylight hours it is generally of equal or greater importance at night. From accident data it is found that the largest accident rate per vehicle mile occurs between the hours of 9 p.m. and 3 a.m. Therefore, most signs intended to warn or regulate moving traffic during hours of darkness should be reflectorized unless they are otherwise fully illuminated.

FIELD STUDIES

To try to develop some standard method of marking and signing no-passing zones various State Highway Departments and other agencies have carried on a series of field studies in which all the various types of no-passing zone markings in use were tried out.

Briefly the procedure in these studies was to select a section of highway upon which zones of restricted sight distance were marked by various types of no-passing zone markings, and to observe and record the reactions of drivers to these markings. To eliminate any possibility of error due to the type of location at which any particular type of marking was placed, the various markings should be rotated so that each type of marking is tried out at each location studied.

The State of Ohio, Department of Highways recently conducted a study mentioned above. The study made seemed to be only for two methods of marking no-passing zones: (1) by no-passing zone signs and, (2) by pavement striping. Pavement markings of the non-directional type, i.e., the type which restricts vehicles in both directions from overtaking and passing through the length of the zone, were eliminated as possibilities. This left only some type of "barrier" marking which could be placed on only one or both sides of the center line. There seemed to be only three methods of distinguishing the barrier line from the center line, viz., by color, by width, and by continuity, i.e., broken center line vs. solid barrier line or vice versa.

Typical of the no-passing zone pavement marking tried in this study by the State of Ohio were:

1. A broken white center line with a continuous white barrier line.

2. A continuous white center line with a broken white barrier line.

3. A broken white center line with a continuous yellow barrier line.

4. A continuous white center line with a continuous yellow barrier line.

In order to determine driver reaction to the different types of markings and to determine driver preference, drivers were stopped and questioned as to their reactions and preferences. The driver was asked whether he saw the marking and whether any of the various types had any greater meaning to him than the others.

In addition to questioning drivers, objective measurements of the relative effectiveness of the various types of markings were made by observing and recording cases of overtaking and passing in the marked zones, and by checking the effect of the markings on vehicle speeds.

The results of the field studies made by the State of Ohio, Department of Highway were summarized as follows:

"1. Drivers feel that no-passing zone markings help them to drive more safely, 97.5% of the drivers questioned confirming this conclusion.

"2. Pavement markings are more effective than signs on the shoulder. There were 50% fewer violations in the zones marked by pavement striping than in the zones marked by signs. Drivers indicated their preference for pavement marking in the ratio of 10 to 1.

"3. The yellow barrier line is more effective along a white line than a white barrier line along a broken white line. Fifty percent fewer drivers disregarded the yellow line than disregarded the white barrier line. Also, approximately 50% more drivers expressed their preference for the yellow barrier line as compared with the white barrier line.

"4. The differentiation of the barrier line from the center line by color contrast is more effective than by differences in width of the center line and barrier line of the same color. Twice as many drivers preferred the 4 inch yellow barrier line along a white center line as compared with a 6 inch white barrier line along a white center line.

"5. Although a yellow barrier line wider than the white center line is slightly more effective than a yellow barrier line of the same width as the white center line, the difference in effectiveness is not material.

"6. Several methods of marking three-lane no-passing zones including the no-passing marking beginning on the left lane line of the center lane 200 feet in advance of the end of the limited sight distance zone and then angling across the center lane for 200 feet to the right lane line of the center lane to permit two lanes of traffic uphill and only one down were tried. Drivers questioned expressed a decided preference for the type of three-lane marking which would require them to stay in a single lane throughout the entire length of the no-passing zone."

The Sub-Committee on Markings for No-Passing Zones of the Special Committee on Administrative Design Policies of the American Association of State Highway Officials set up standards for marking and signing no-passing zones on two-lane and three-lane highways which were approved by the American Association of State Highway Officials effective February 17, 1940. These standards are as follows:

"1. No-passing zones for traffic in either direction on a highway, as defined by the Special Committee on Administrative Design Policies, shall be marked by an auxiliary or barrier stripe placed to the right of the normal center line, i.e., in the lane of traffic that it is to govern.

"2. The barrier stripe shall be a solid yellow line. In order that the barrier line shall be distinctive, the normal center line shall be either white or black. It may be of solid or broken type.

"3. The barrier line shall not be narrower than the normal center line, nor in any case less than 2 inches wide. It should preferably be at least 6 inches wide.

"4. The barrier line shall be separated from the normal center line by a distance equal to half the width of the center line.

"5. The combination no-passing stripe shall be identical as applied to both two-lane and three-lane roads.

"6. On a two-lane road the no-passing marking shall separate the two lanes throughout the no-passing zone. On a three-lane road the combination no-passing stripe shall start from the left-hand lane marking line and extend at an angle of not less than 20 to 1 across the center lane to meet the right-hand lane line at the beginning of the no-passing zone, and thence will extend along the lane line to the end of the zone.

"7. The same design of no-passing stripe shall be used for all types of no-passing restrictions.

"8. The use of signs in addition to the above specified markings to designate no-passing zones shall be governed by local legal requirements or otherwise, at the option of the State, but when signs are used they shall conform to the specifications set forth in the Manual on Uniform Traffic Control Devices for Streets and Highways."

Since the above standards have been adopted a number of states have put them into practice. In making this study the writer has made a survey to determine to what extent the various states have adopted and put the standard no-passing zone markings, as recommended by the American Association of State Highway Officials, into use. Replies were received from 45 states.

Of these states, 36 indicated that they are using no-passing zone markings of some type and 1 more reported that they plan to adopt the standard markings. Twenty-three replies commented that there had been favorable acceptance of the no-passing markings in their respective states. The other states had no data concerning this question.

LOCATING NO-PASSING ZONES

No-passing zones shall be indicated separately for traffic in each direction. They shall be zones in which the sight distance ahead is less than 500, 600, 800, 1000, and 1200 feet for vehicular speeds of 30, 40, 50, 60, and 70 miles per hour respectively.

Sight distance shall be measured from the height of eye and top of a passenger type vehicle, both of which are assumed to be $4\frac{1}{2}$ feet above the pavement surface.

The crew will consist of two men for each district. They will be equipped with an automobile, a 100 foot steel tape, and standard level book for recording the log of their work. Each man should have three large red flags, two of which should be fastened conspicuously to his clothing. Each should also have a whistle for signalling, a small bucket of white paint and a brush for marking the ends of no-passing zones.

Before beginning and after completing the work the accuracy of the mileage indicator of the speedometer in the automobile used shall be determined and the results noted in the note book. The error in the speedometer may be determined by driving the automobile, at a moderate rate of speed, over one or more consecutive road sections of known length, the total of which is approximately 10 miles. A marked Federal-Aid project is satisfactory for this purpose because the observer can accurately determine the speedometer reading at each end of the project. Before beginning the test run, the tires should be inflated to the proper pressure and each morning before work is started the tires should be inflated to that same pressure.

Each morning the crew should enter in the log book the date, weather conditions, and a detailed description of the starting point and the speedometer reading at this point.

The starting point on any one road should always be at exactly the same place as where the last entry in the book was made on that road. Starting point should be described with respect to junctions of other roads, county lines or large bridges. A tie to stores and other such places will be of no value.

The crew will then proceed to a point where it appears there is a sight restriction. As soon as the crew is within the area where this restriction exists, they will park the car and by pacing, separate themselves the required distance for the predominate travelled speed on the highway. They will then proceed to pace toward the restricted section until all of the body of the lead man is out of sight except his head and shoulders. At this point the lead man will make a mark in the LEFT traffic lane which will indicate the end of the no-passing zone for the cars in that lane. The rear man will make a mark in the RIGHT lane which will indicate the beginning of the no-passing zone for the cars in that lane. On a given signal both men will pace forward until the lead man reappears. As soon as his head and shoulders come in sight the man in the rear will give a signal at which time both will stop. The lead man will place a mark in the LEFT traffic lane which will indicate the beginning of the no-passing zone in that lane, and the rear man will place a mark in the RIGHT traffic lane indicating the end of the no-passing zone for traffic in that lane. The marks should be at least 4 inches in diameter and located about six inches to the side of center line in their proper lanes.

It will be noted that in all cases the man in lead paints the end and beginning of no-passing zones in the LEFT lane while the man in the rear paints the beginning and end of no-passing zones in the RIGHT lane.

On horizontal curves, the men should locate themselves on the center line of the road and the beginning and end of zones will be painted just as the lead man starts to go out of sight because of permanent obstructions. Extreme care must be taken to avoid being hit by vehicles while working on these curves.

On the vertical curves the men should walk on the left shoulder facing the traffic. Here again extreme caution must be taken in stepping out to the center of the road for painting the beginning and end of zones.

In stopping the car at no-passing zones, the automobile must always be parked well off the road and never at the crest of the hill or on a blind curve. The general rule should be that the car must be stopped before the maximum point of restriction is reached and while there is at least 500 feet sight distance ahead. The car should never be turned around or backed up as this will introduce an error into the log record.

Only permanent or semi-permanent objects restricting sight distance should be considered in the marking of no-passing zones. Permanent brush or trees should be considered as having leaves when marking no-passing zones. However, if it is possible to remove the brush or trees to get sufficient sight distance, this should be done rather than the marking of a no-passing zone. In no case should removable brush or trees be the determining factor in establishing of a no-passing zone.

When no-passing zones for the same direction of travel come within 1000 feet or less of each other, they should be combined into one zone. Where a no-passing zone determined according to the above method is less than 200 feet long, it need not be marked.

Four lane highways need no such passing restrictions.

Both men should practice pacing together before attempting to locate any zones and should attempt to coordinate their walking so they will maintain a constant distance between themselves at all times. Frequent checks should be made on the paced distance of these zones so that corrections can be made as required.

CONCLUSION

Markings are applied to pavement surfaces for the purpose of increasing safety on the highways. This is accomplished by the warning which the Markings provide of unusual or dangerous conditions, and by the increased safety which results when traffic is moving in an orderly manner. The fact that the capacity of many highways can be increased by the proper regulation of traffic flow which results from correct pavement marking, is of almost equal importance.

Every effort has been made to reduce these Standards to the simplest terms which will produce the desired results. It is believed that they will apply to all but the most unusual conditions.

Isolated cases may occur where the Standards will not properly fit the situation. In such cases the Standards may be modified as necessary. These instances should be kept to a minimum. The modifications should depart from the Standards only to the extent necessary to adapt them to the situation, and they should conform to the basic principles of the Standards.

It is fundamental that the most important thing in connection with any system of signs or markings is uniformity. The fact that a motorist will be confronted by the same type of marking wherever he may travel throughout the nation and that these markings will mean exactly the same thing, wherever they are encountered, is of far more value than any improvement in them which may be conceived by an individual. For this reason, no deviation from these Standards will be permitted, except as covered by the preceding paragraph.

On vertical curves sight distance will be measured from a point $4\frac{1}{2}$ feet above the pavement to a point $4\frac{1}{2}$ feet above the pavement. These dimensions are exact, not approximate. A target should be used on the front rod and the observer should use a mark on a picket or other device to ensure that his eye is $4\frac{1}{2}$ feet above the pavement.

On horizontal curves on two-lane pavements, sight distance will be measured from the center of the right hand lane to the center of the left hand lane.

On horizontal curves on three-lane pavements, when sight distance is measured in the direction which places the right hand lane on the inside of the curve, sight distance will be measured from the center of the right hand lane to the center of the center lane. When sight distance is measured in the direction which places the right hand lane on the outside of the curve, sight distance will be measured from the center of the center lane to the center of the inside lane.

On horizontal curves on four lane pavements, sight distance will be measured from the center of the right hand inner lane to the center of the left hand inner lane.

When horizontal and vertical curves coincide, the methods prescribed for determining sight distance on horizontal curves will be followed, but the measurement will be made from a point $4\frac{1}{2}$ feet above the pavement to a point $4\frac{1}{2}$ feet above the pavement, as prescribed for vertical curves.

The terms "right hand" and "left hand" refer to the direction in which sight distance is measured at each end of the zone of limited sight distance. They bear no relation to the inside and outside of the curve.

When sight distance is measured in the early spring, the future growth of foliage must be taken into account. In many cases, however, arrangements may be made to trim this foliage, which will eliminate the necessity for restrictive markings.

In making sight distance surveys, many instances will be observed where a small amount of work, or the acquisition of inexpensive right of way, will provide adequate sight distance. Notes should be taken of these locations and the possibility of improving sight distance, rather than painting restrictive markings, should be taken up with the maintenance department.

Dimensions and spacings of each type of line are shown on Page 71.

The "broken line" is used for the purpose of defining traffic lanes. It is not used as a prohibition against crossing, but merely to guide traffic in the lane which it should follow.

The "single solid line" is used primarily for the purpose of separating opposing streams of traffic. It is a warning line. Traffic should not cross it, except when passing, and then only when conditions permit. It may be used on short stretches of two-lane pavement where it is desirable to confine traffic to one lane in each direction but where the standards do not permit the use of the Double Line.

The "double line" is used only where a potential danger exists. It is intended as a positive barrier. In order to ensure respect and obedience, its use should be kept to a minimum.

If solid on both sides, it may not be crossed from either side, and on two and three-lane pavements prohibits passing from either direction. If solid on one side and broken on the other, cars may cross if the broken line is on their side. They may not cross if the solid line is on their side. It prevents passing by a motorist whose sight distance is limited, without prohibiting passing by one traveling in the opposite direction and whose sight distance is not limited.

"Edge lines" shall always be used to guide traffic into narrow sections of pavement as shown on Pages 76, 77,and 78 where the offset of the wider pavement is greater than one-half the lane width.

The "Unlawful To Cross Solid Line On Your Side" sign will be placed at the beginning of Double Lines; but in order to avoid an excessive number of signs along the highway, not more than one sign per side per five miles will be used.

At locations where the pavement narrows, the "Narrow

Pavement", the "Narrow Bridge" or the "One Lane Bridge" sign will be placed 300 feet in advance of the point where the pavement narrows or 300 feet in advance of the bridge.

When the length of a zone of limited sight distance is less than 550 feet, the distance in which the driver's vision is limited will not exceed 50 feet, at each end of the zone. Zones whose total length is not greater than 550 feet will therefore not be marked for limited sight distance. When the length of a zone of limited sight distance is less than 1000 feet, the sum of the distances at each end in which the driver's vision is limited will not equal the total length of the zone. There will therefore be a short distance in the center of the zone in which sight distance is not limited in either direction. In such cases, the Solid and Broken Lines will be continued from each end of the zone to a common point. In most cases this will be the center of the zone. These Standards provided for the starting of the Release Line (broken line of the Double Line) at the point where sight distance becomes more than 500 feet. On high speed roads, and in other locations where an element of danger is introduced by this early release, the solid line may be continued past the point of 500 foot sight distance to the point where it is considered safe to permit passing. In no case, however, should the solid line be continued past the point where the sight distance becomes 800 feet. It should be borne in mind that the standard sight distance for beginning the release line is 500 feet, and that beginning the release line at a greater sight distance is the exception, not the rule.

On horizontal and vertical curves with a sight distance of 500 feet or less, a Double Line will be marked on the center line of both black top and concrete pavements, as shown on Page 72, for the entire distance in which the sight distance is less than 500 feet in either direction. On two-lane concrete pavement with no longitudinal center joint, a Broken Line will be marked on the center line for the entire length of all tangents, and of all curves with a sight distance greater than 500 feet. If a longitudinal center joint exists in the correct location, no center line will be marked, except in fog areas or unless the pavement is discolored or patched to the extent that visibility or continuity of the center joint is impaired. On two-lane black top pavements, a Broken Line will be marked on the center line for the entire length of all tangents, and of all curves with a sight distance greater than 500 feet.

Pavements less than 27 feet wide will not be treated as three-lane pavements. All three-lane pavements will be marked according to these Standards, both black top and concrete, and regardless of whether or not longitudinal joints exist. On horizontal and vertical curves with a sight distance of 500 feet or less a Double Line will be marked diagonally and on the center line for the entire distance in which the sight distance is less than 500 feet in either direction. The broken line on the side of approaching traffic will be discontinued 100 feet back of the beginning of the double diagonal. On tangents and on curves with a sight distance greater than 500 feet, the entire length will be divided into three lanes by marking two Broken Lines.

All four-lane pavements will be marked according to these standards, both black top and concrete, and regardless of whether or not longitudinal joints exist. On horizontal and vertical curves with a sight distance of 500 feet or less, a Double Solid Line will be marked on the center line, as shown on Page 75, for the entire distance in which the sight distance is less than 500 feet in either direction. On tangents, and on curves with a sight distance greater than 500 feet, the entire length will be divided into four lanes by marking a Single Solid Line on the center line and Broken Lines on the quarter points.

Methods to be used in guiding traffic into narrow sections of pavement are shown on Pages 76, 77, and 78. If the center lines of the top two sections are eccentric, the methods shown should be adapted to fit the case. In cases where limited sight distance is involved, the rules for marking such locations will be followed. At a one lane bridge the lane markings shall be discontinued at a point 300 feet in advance of the bridge. The "Narrow Pavement", the "Narrow Bridge" or the "One Lane Bridge" sign shall be placed 300 feet in advance of the point where the pavement narrows or 300 feet in advance of the bridge.

Lanes on both sides of the mall on divided highways will be marked by Broken Lines for their entire length on both tangents and curves. The markings for restricted sight distance will not be used. In determining the number of lanes to be marked, no less than 9 feet shall be considered as a lane width. Due to the wide variation possible in the construction of a transition from a two-way highway to a divided highway, it is not practical to show by sketches or to describe the transition markings for each condition which may be met in the field. Three typical examples are described in this study which cover cases where the center lines are concentric and where the mall of the divided highway ends where the wide pavement begins to narrow. The examples cover two, three, and four-lane pavements entering divided highways which have two lanes of traffic in each direction. Where the wide pavement extends beyond the mall or where the center line eccentricity is extreme, the pavement area assigned to traffic in one direction may be considerably larger than that assigned to traffic in the other direction.

Approach markings in advance of the mall of a divided highway will consist of two sets of diagonal Double Solid Lines. These lines will begin at the end of the mall at points one foot from either edge and converge on the center or lane line of the narrower pavement, then continue as a Double Solid Line for a distance of 100 feet along the center or the lane line. The length of the diagonal Double Solid Lines will be dependent upon the width of the mall, limited by the length of the transition. Normally the length of the diagonal Double Solid Lines will be 100 feet plus 10 times the width of the mall.

For example, the length of the diagonal Double Solid Lines approaching a 10 foot mall will be 100 feet plus 10 times 10 feet or 200 feet. A 20 foot mall would require diagonal Double Solid Lines to be 300 feet long. Where the length of the transition pavement permits, the minimum length of the diagonal Double Solid Lines will be 200 feet. As an example, a divided highway with a 6 foot mall would, according to the formula, require the diagonal Double Solid Lines to be 160 feet in length. This should be increased to the minimum of 200 feet. There may be cases where the computed or the prescribed minimum length of the diagonal Double Solid Lines will place the point of convergence beyond the point where the narrow pavement begins. In these cases, it will be necessary to reduce the length so that the diagonal Double Solid Lines end at the point where the narrow pavement begins. This is necessary to avoid the reduction in lane width which will occur if the point of convergence falls within the narrow pavement.

When approaching a divided highway from a two-lane pavement, the Broken Line along the center line will be stopped 100 feet in advance of the point of convergence of the diagonal Double Solid Lines. A Double Solid Line will be marked along the center line for a distance of 100 feet to the point where the diagonal Double Solid Lines converge, with the two sets of diagonal Double Solid Lines extending to the end of the mall at points 1 foot off the edges. The length of the diagonal Double Solid Lines will be determined as outlined in the section on Transitions above. The Broken Line separating the lanes for traffic entering the divided highway will start at the beginning of the mall. The Broken Line separating the lanes of traffic leaving the divided highway will be stopped 100 feet in advance of the end of the mall.

When approaching a divided highway from a three-lane pavement, the diagonal Double Solid Lines will converge on the left lane line. The Broken Line on this lane line will be stopped 100 feet in advance of the point of convergence of the diagonal Double Solid Lines. A Double Solid Line will be marked along the left lane line for a distance of 100 feet to the point where the diagonal Double Solid Lines converge, with the two sets of diagonal Double Solid Lines extending to the end of the mall at points 1 foot off the edges. The length of the diagonal Double Solid Lines will be determined as outlined in the section on Transitions above. The Broken Line separating the lanes for traffic entering the divided highway will be continued from the three-lane pavement through the transition and on the divided highway, with that portion within the transition area parallel to the corresponding diagonal Double Solid Line. The Broken Line separating lanes of traffic leaving the divided highway will be stopped 100 feet in advance of the end of the mall.

When approaching a divided highway from a four-lane pavement, the diagonal Double Solid Lines will converge on the center line. The Single Solid Line on the center line will be stopped 100 feet in advance of the point of convergence of the diagonal Double Solid Lines. The Double Solid Line will be marked along the center line for a distance of 100 feet to the point where the diagonal Double Solid Lines converge, with the two sets of the diagonal Double Solid Lines extending to the end of the mall at points 1 foot off the edges. The length of the diagonal Double Solid Lines will be determined as outlined in the section on Transitions above. The Broken Lines separating the lanes for traffic entering and leaving the divided highway will be continued from the four-lane pavement through the transition and on the divided highway, with that portion within the transition area parallel to the corresponding diagonal Double Solid Lines.

In order to prohibit the use of the pavement between the diagonal Double Solid Lines, the area between these lines will be hatched in the direction of traffic by transverse lines 24 inches wide, at 45 degrees to the center line of the transition pavement. The open space between the transverse lines shall be 6 feet measured along said center line. These transverse lines shall generally begin at a point 50 feet from the point of convergence and continue through the triangular area bounded by the diagonal lines and the mall.

Edge lines as described on Page 55 shall be marked in the transition area to guide traffic from the divided highway entering the two-way highway in all cases where such traffic is shunted to the left and where the offset of the pavement edges is greater than ½ a lane width. The 40 to 1 ratio as shown on the plates for narrowing pavements is desirable for edge lines. However, the offset in the pavement edges between the two-way and divided highways is likely to be so great that an extremely long edge line would have to be painted. An edge line so painted would also tend to reduce the area of useable pavement. In such cases, the edge lines may be painted parallel to the edge of the transition pavement.

In some areas, zones where sight distance is less than 500 feet occur with great frequency, and special treatment becomes necessary when the end of one such zone is so close to the beginning of another that the Standard Markings will not apply. In such cases the following instructions will govern.

For three-lane pavements with gap 400 feet or less, the diagonal lines will be omitted, and the Double Lines will be continued on the center line of the pavement to the zone ends. The two zones will be connected by a Single Broken Line painted on the center line of the pavement. On high speed roads a Single Solid Line may be used instead of the Single Broken Line. For two-lane pavements with gap 200 feet or less, connect the ends of the zones by a Single Broken Line painted on the center line. On high speed roads a Single Solid Line may be used instead of the Single Broken Line.

The use of the Standard Markings through populated areas will be determined by local conditions. If cars park on the pavement it may be necessary to omit lane lines. A Single Solid Line on the center line of the pavement will usually assist in creating an orderly flow of traffic. On narrow pavements, especially if parked cars encroach, it may be found that even the center line should be omitted. As traffic will not drive close to a curb, lane lines in curbed sections may not be effective. In most cases they should not be painted, a center line being sufficient. In approaching curbed sections, avoid the use of lane lines which will lead traffic into parked cars. Decisions with regard to marking through villages and hamlets should be based upon local conditions, not the type of political subdivision. For example, outlying portions of highways through villages, which are not built up, should be marked as though the territory were rural. On the other hand, thickly settled hamlets should be treated as though they were villages.

The locations at which the various types of markings prescribed by these standards are used should be selected with extreme care. They should not be left to the judgment of the workmen who do the painting, but should be determined in the field by members of the District Engineering Staff. Preliminary location may be made from record plans, but the final determination must be made in the field as the result of actual measurements and sight distance surveys, as described on Page 53, and should be marked by stakes or other methods for the guidance of the painters. The marking of pavements will be handled as a District matter. The application of the paint should be performed by crews trained in handling the paint machines, and who will gain in skill and experience as they continue this work. They should be shifted from county to county as the work requires. The application of these Standards to a pavement is more than a matter of painting lines. In effect, it is the installation of a system of guiding traffic on that particular stretch of highway. To be of value, the system must be applied in its entirety, not in part. On any highway which is selected for marking, the Standards will therefore be applied completely to the entire length between two termini. If the double and single lines are marked separately, the double lines must always be marked first, as their absence, in the presence of single lines, may give incorrect information to traffic and may lead to accidents.

SUMMARY

In the study just completed, 37 of 45 states replying to the questionaire sent them reported that they are using special pavement markings, signs, or both pavement markings and signs to mark zones where overtaking and passing is hazardous because of restricted sight distances or for other reasons. The fact that all but a few of the states are using some system to mark no-passing zones is evidence that such marking is not only desirable but that there is a demand that such zones be marked.

This survey also disclosed that there was a serious lack of uniformity. The lack of uniformity in the methods of markings was more significant than the fact that so many states were marking no-passing zones. The analysis of the reports made by the various states on their methods of marking no-passing zones showed that 5 states were using signs alone; 11 states marked them by special striping with no sign; and 21 states used pavement striping together with signs.

Of the 32 states using pavement markings to indicate where overtaking and passing would be hazardous, 22 states continued the special striping throughout the entire zone--- 14 states using a continuous single line and 8 states a double or triple continuous line. Ten other states used types of markings which restricted the driver only throughout the length of the zone in which sight distance was restricted. Of these 10 states, 4 restricted passing when a yellow line was on the right of a black or white center line; 1 state restricted passing when a white line was on the left side of a yellow center line; 2 states restricted passing when a white line was on the right side of a yellow center line; 2 states restricted passing when a broken line was on the right of a continuous center line of the same color; and 1 state used a solid line on the right side of a broken center line of the same color.

Most of the States are now using some design of striping that places a "barrier" line as the right-hand stripe in some sort of combination striping through a no-passing zone. In 1940 the American Association of State Highway Officials adopted a standard which called for making the normal center line white or black with the "barrier" line yellow. This standard was accepted and used by more than a third of the states, and probably would have had more extended use if yellow paint had been obtainable during the war. There have been many variants of the basic "barrier" line scheme, however. In some states a yellow center line with a white "barrier" line has been preferred. A considerable group of the states, especially in the East, have preferred to use a single color, white or yellow, and have distinguished the center line from the "barrier" line by marking the former "dashed" or "broken" and the latter "solid" or "unbroken". In single color markings, it is usual to use, instead of a "barrier" line on one or both sides of a center line, a double line, of which the right-hand line is either solid or broken, depending on whether it is a "barrier" line. Both lines are solid where passing is prohibited in both directions. When a broken line is to the right, passing is permitted.

In a recent revision of standards the Joint Committee on Uniform Traffic Control Devices, Public Roads Administration has recommended that the center line be a broken white line, and that the "barrier" line be a solid yellow or white line, preferably yellow.

There is considerable difference in the standards for determining no-passing zones in terms of sight distances. Some states attempt to take design speed into consideration, while others use a fixed minimum of 500 feet or other distance that has been found suitable to the local traffic. Sight distance should be measured between eye and top of vehicle both 4½ feet above the pavement surface.

Signs used to mark no-passing zones, usually in conjunction with pavement markings, have also varied from state to state. The Manual on Uniform Traffic Control Devices, Public Roads Administration provides for signs reading "No Passing" and "End No Passing Zone" though their use is not mandatory. Some states have tried to design signs explaining the markings, with such wording as "No Passing if yellow line is in your lane", or by diagrams interpreting the striping.

Methods will vary when a program of proper education and speed zoning has been established on our highways. No-passing zone for the purpose of marking two and three-lane pavements shall be one in which the sight distance ahead is less than

500, 600, 800, 1000, and 1200 feet for assumed design speeds of 30, 40, 50, 60, and 70 miles per hour respectively. No-passing zones shall be determined and indicated separately for traffic in each direction. No-passing zones for traffic in opposite directions may overlap or there may be a gap between their ends.

The system of marking pavements of two and three-lane roads shall restrict passing within the limits of no-passing zones and shall differentiate between traffic in opposing directions so that traffic in each direction will not be restricted from passing when the road opens up to view. The system of marking pavements of three-lane roads shall restrict traffic in each direction to the right lane within the limits of a no-passing zone. Diagonal striping across the middle lane shall be provided approaching the beginning of a no-passing zone. The diagonal striping shall indicate that it must not be crossed by traffic approaching the no-passing zone but may be crossed by traffic in the opposite direction.

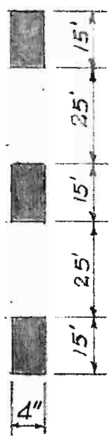
Intersecting roads for some distance from the intersection should be considered no-passing zones for traffic approaching the intersection. Where one road is a preference road the non-preference road only may be considered a no-passing zone. No-passing zones at intersections may be marked in the same manner as other no-passing zones except that three-lane roads with STOP control should have the restrictive stripe on the center line instead of on the right lane line, and where STOP control on three-lane roads is affected by traffic lights, restrictive stripes may be omitted.

The system of marking pavements for no-passing zones is primarily intended to be used for restricted vertical sight distance or a combination of restricted vertical and horizontal sight distance. The restriction in horizontal sight distance alone usually is obvious, while the impairment of vertical sight distance on tangents generally is not realized by the average motorist.

This study is subject to future modification. It is realized that new situations will arise with advanced standards of highway construction and the development of basic materials which will perform functions in their employment in traffic control devices more satisfactorily than those now in use.

STANDARD MARKINGS

BROKEN LINE



Used to define traffic lanes. Traffic may cross.

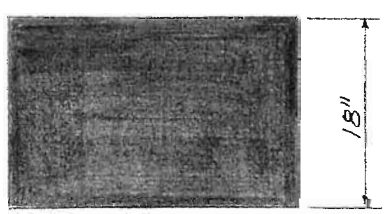
SINGLE SOLID LINE

Used to separate opposing streams of traffic. Traffic may cross under certain conditions.

DOUBLE SOLID LINE

Used to prohibit crossing of line. Traffic must not cross from either side.

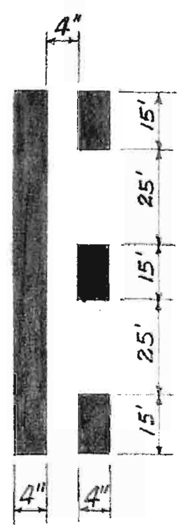
STOP LINE



Paint across lanes in which traffic is to be stopped for signal, stop sign, etc.

SOLID AND BROKEN LINE

cars must not cross from this side



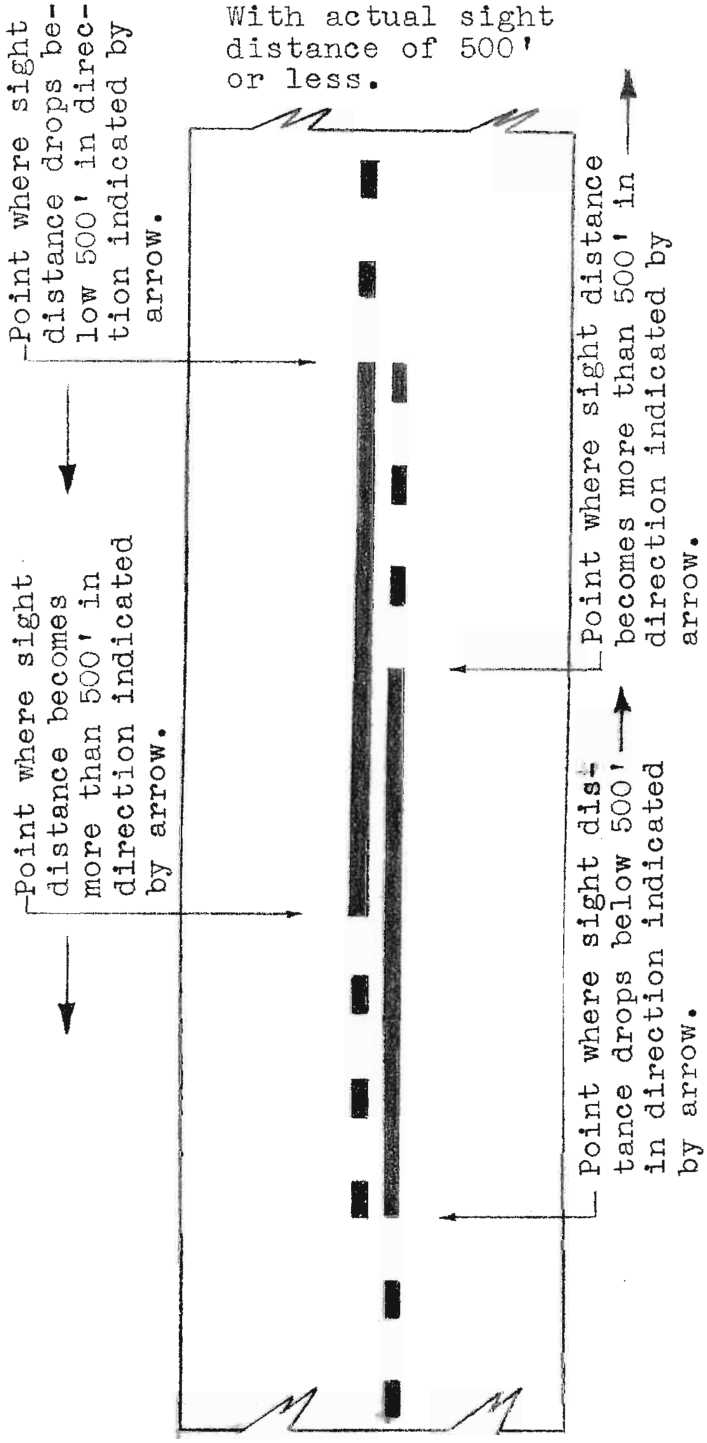
cars may cross from this side

Permits crossing from one side only.

LANE MARKING FOR TWO LANE PAVEMENTS

ON VERTICAL AND HORIZONTAL CURVES

With actual sight distance of 500' or less.



ON TANGENTS AND CURVES WITH MORE THAN 500' SIGHT DISTANCE

Black Top

Paint broken line entire length on center line. May eliminate on pavements carrying less than 500 vehicles in 12 hours.

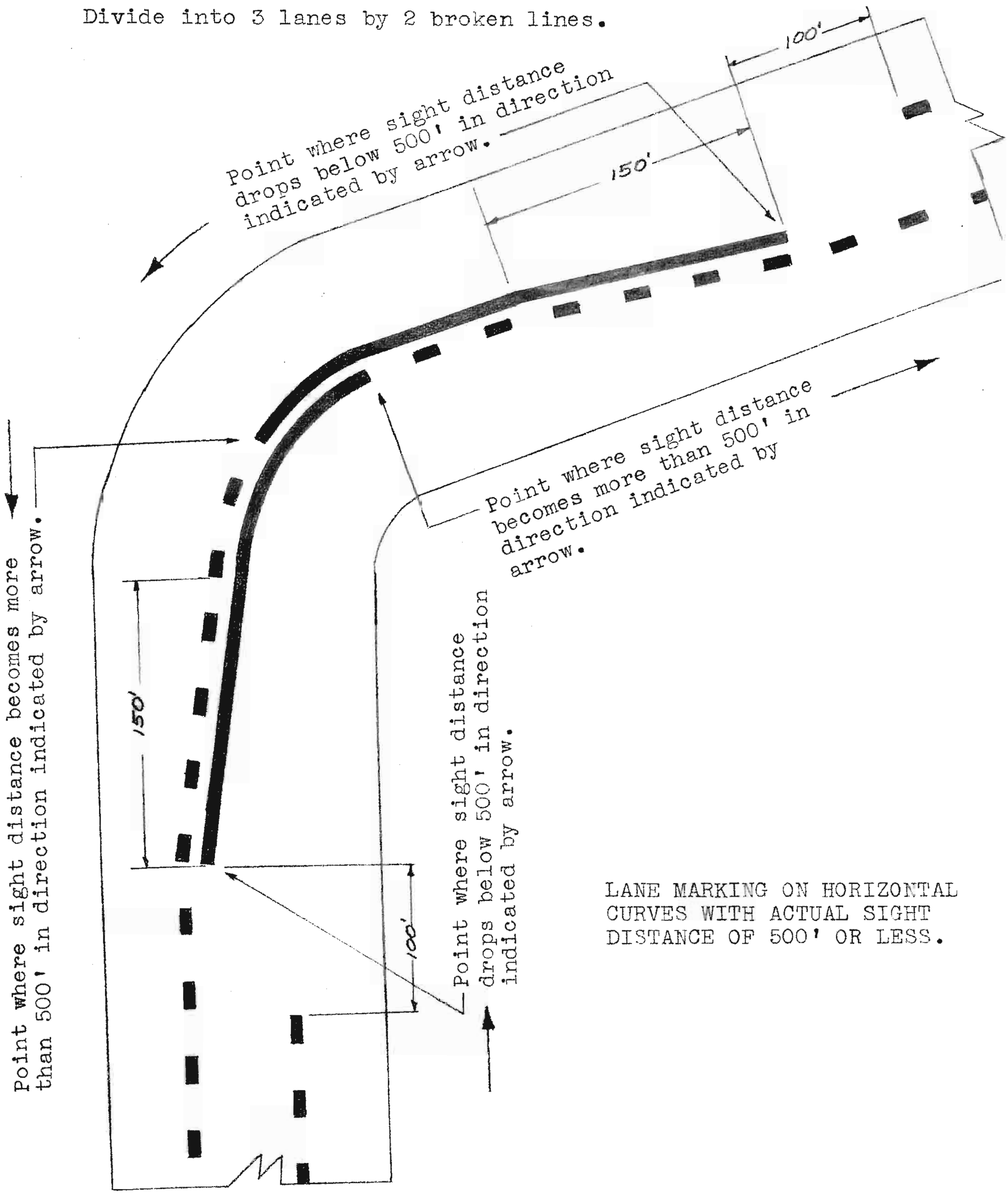
Concrete

Paint broken line on center line only if no center joint. Broken line may be used if the continuity or visibility of the center joint is impaired by frequent patching or discolored pavement.

THREE LANE PAVEMENTS

On Tangents And Curves With
More Than 500' Sight Distance.

Divide into 3 lanes by 2 broken lines.

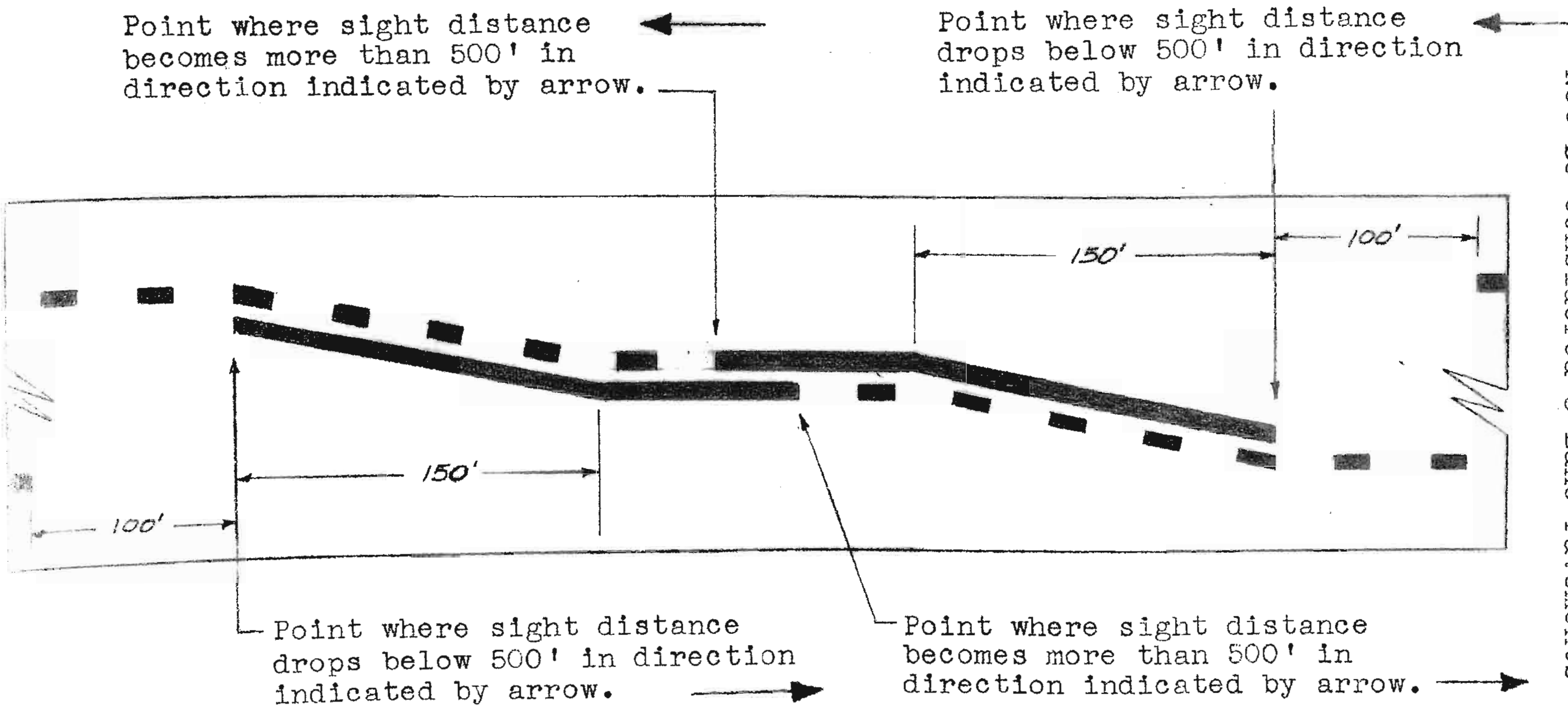


LANE MARKING ON HORIZONTAL
CURVES WITH ACTUAL SIGHT
DISTANCE OF 500' OR LESS.

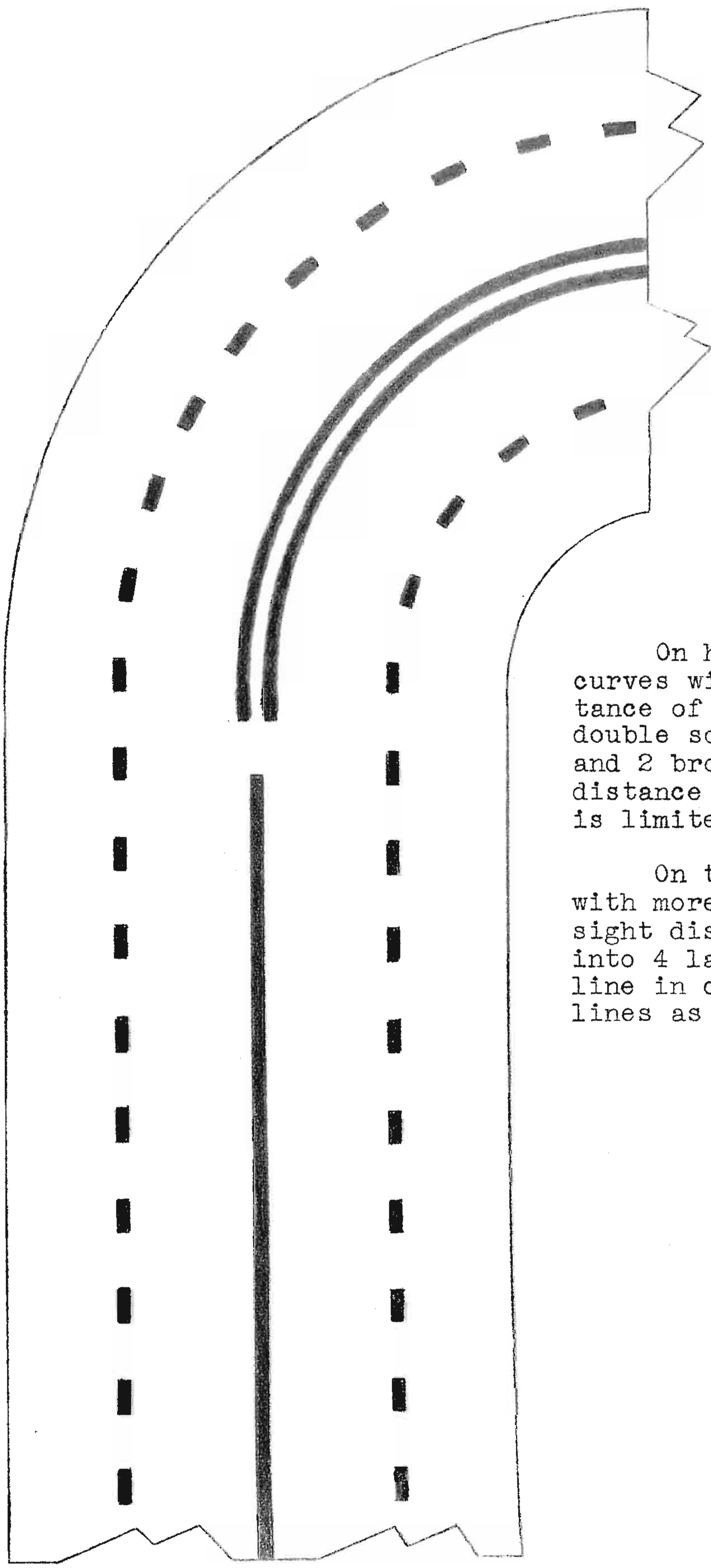
THREE LANE PAVEMENTS

On Vertical Curve With
500' or Less Sight Distance

Pavements Less Than 27' Wide Shall
Not Be Considered 3-Lane Pavements



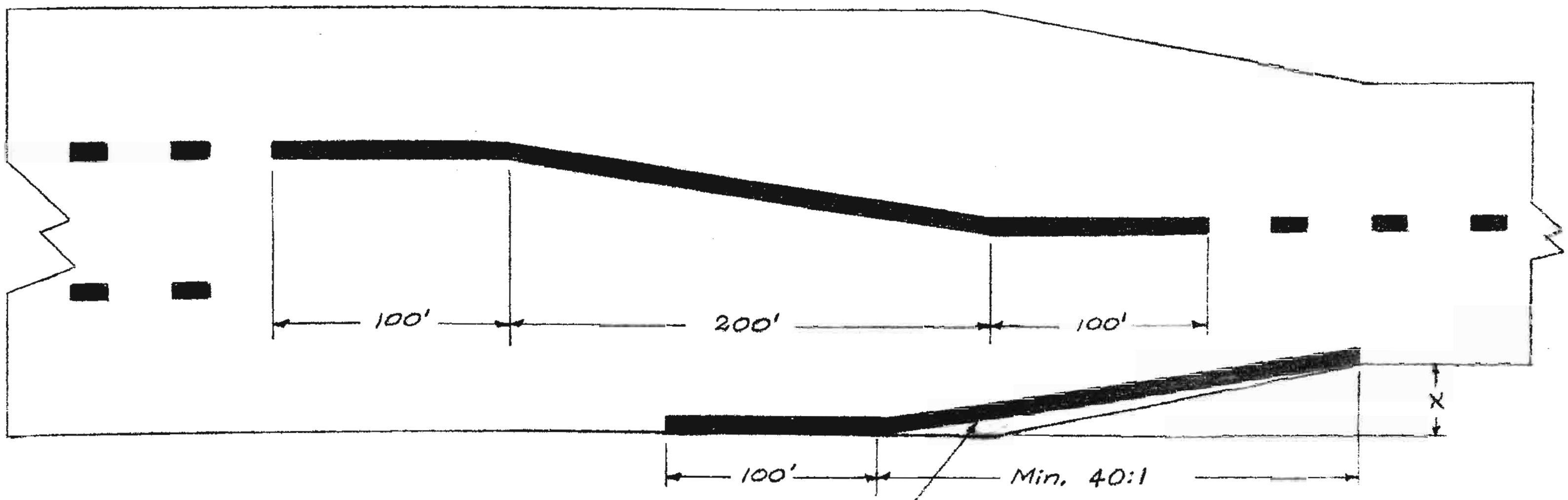
FOUR LANE PAVEMENTS



On horizontal and vertical curves with actual sight distance of 500' or less, use double solid line in center and 2 broken lines for entire distance that sight distance is limited.

On tangents and curves with more than 500' actual sight distance divide pavement into 4 lanes by use of solid line in center and 2 broken lines as shown.

Note: In cases where limited sight distance is involved, follow fules for marking limited sight distance.

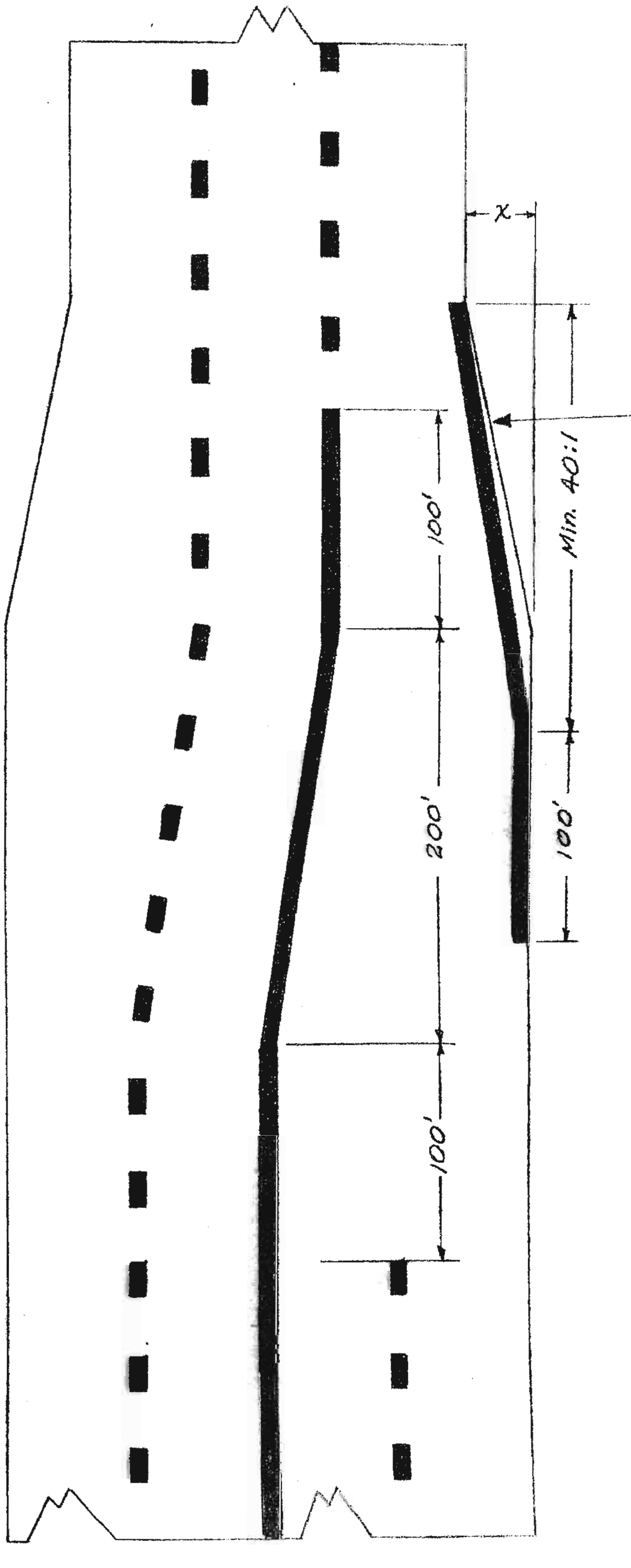


EDGE LINE Paint edge line where "X" is greater than ½ the lane width, otherwise edge line is optional.

THREE LANE PAVEMENTS NARROWING TO TWO LANES

FOUR LANE PAVEMENTS

NARROWING TO THREE LANES

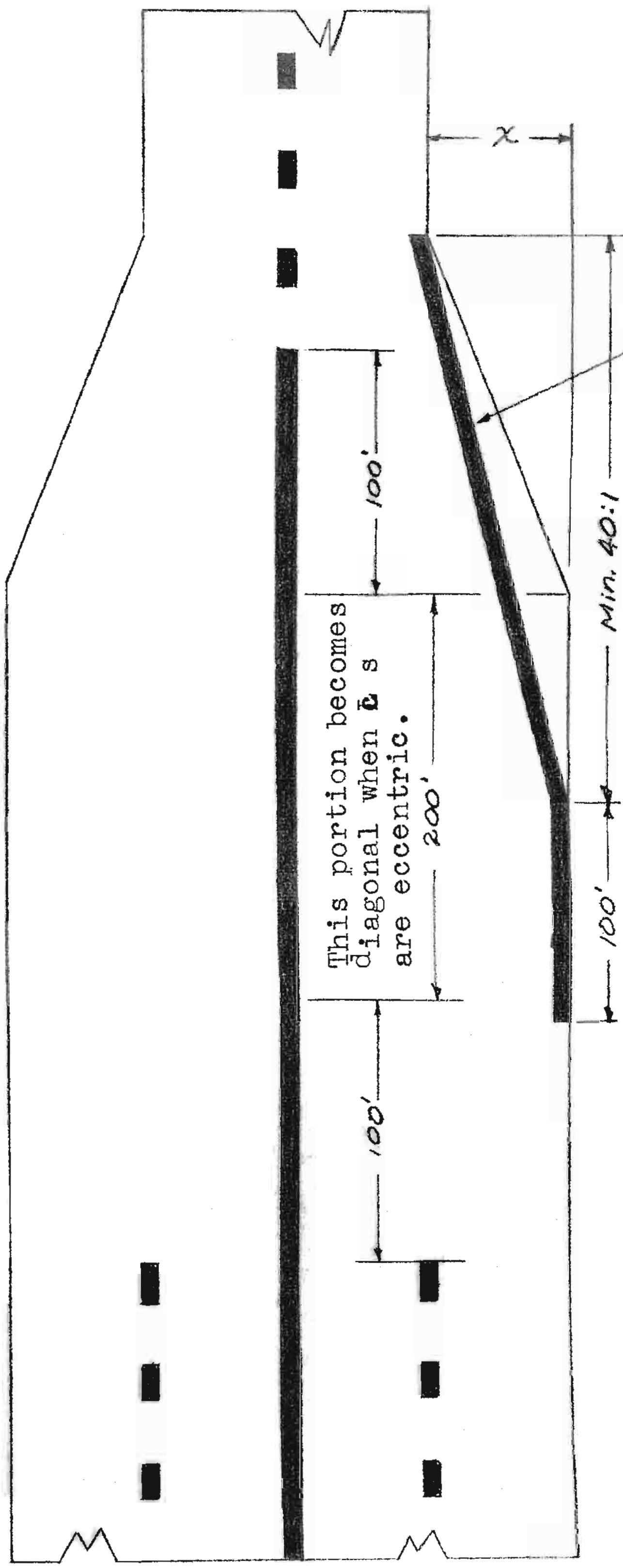


EDGE LINE Paint edge line where "X" is greater than ½ the lane width, otherwise edge line is optional.

Note: In cases where limited sight distance is involved, follow rules for marking limited sight distance.

FOUR LANE PAVEMENTS

NARROWING TO TWO LANES



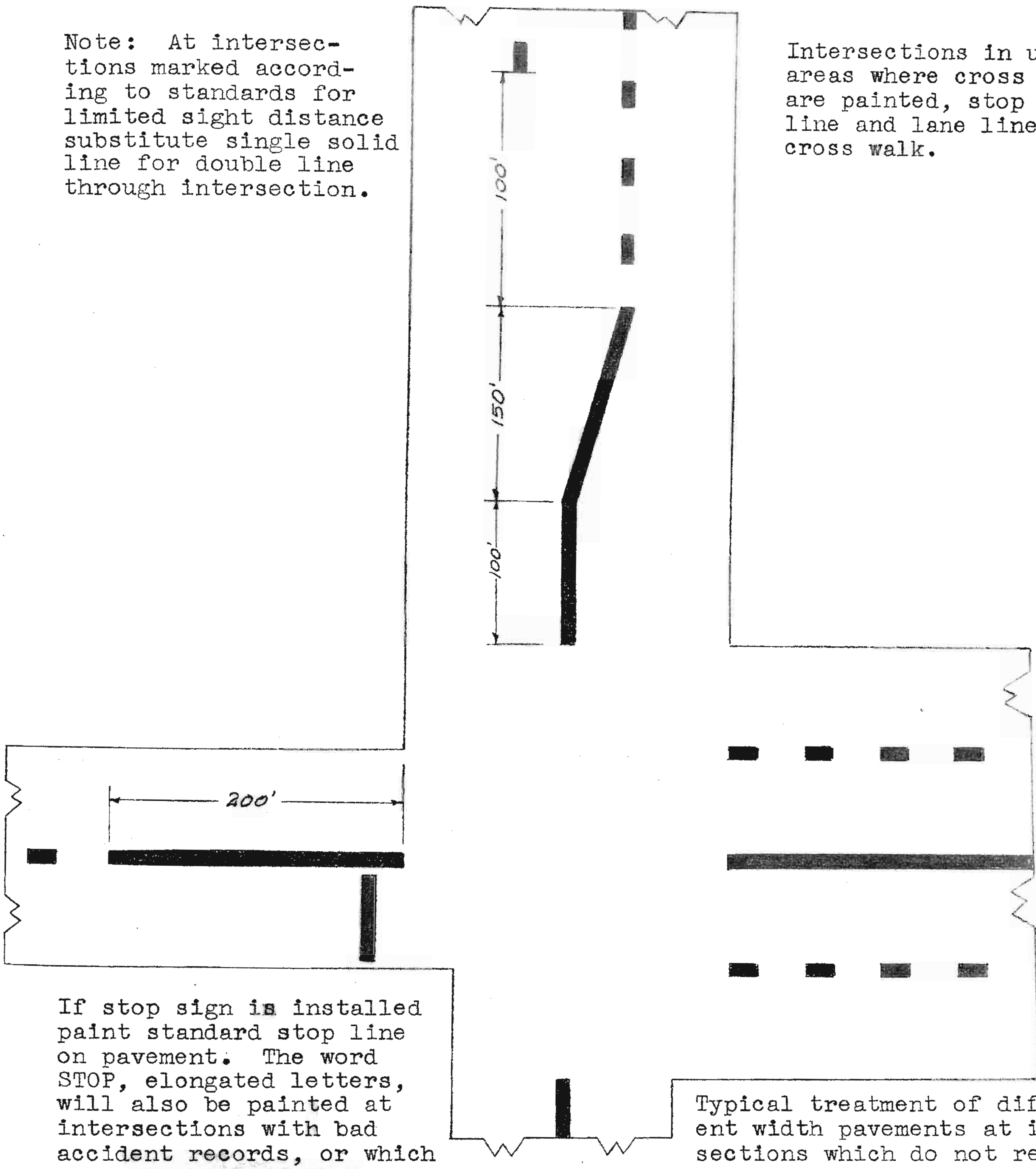
EDGE LINE Paint edge line where "X" is greater than ½ the lane width, otherwise edge line is optional.

Note: In cases where limited sight distance is involved follow rules for marking limited sight distance.

INTERSECTION MARKINGS

Note: At intersections marked according to standards for limited sight distance substitute single solid line for double line through intersection.

Intersections in urban areas where cross walks are painted, stop center line and lane lines at cross walk.



If stop sign is installed paint standard stop line on pavement. The word STOP, elongated letters, will also be painted at intersections with bad accident records, or which there is lack of obedience to the STOP sign.

Typical treatment of different width pavements at intersections which do not require marking according to standards for limited sight distance.

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